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(56) Documents Cited
GB 2124051 A EP 0517626 A1 US 5247190 A

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(54) **Sensing device comprising coplanar light emitter and detectors**

(57) A unitary sensing device is provided which has light emitting regions P2, P4 in the same plane as an array of light detecting regions P1, P3, P5. The light emitters and detectors are formed between electrodes 4, 8 in regions of an electroluminous semiconductor polymer layer 6, preferably polyphenylene vinylene (PPV). The light emitting region may be provided as a continuous strip adjacent a strip of the sensing elements. A variety of operating circuitry is described.

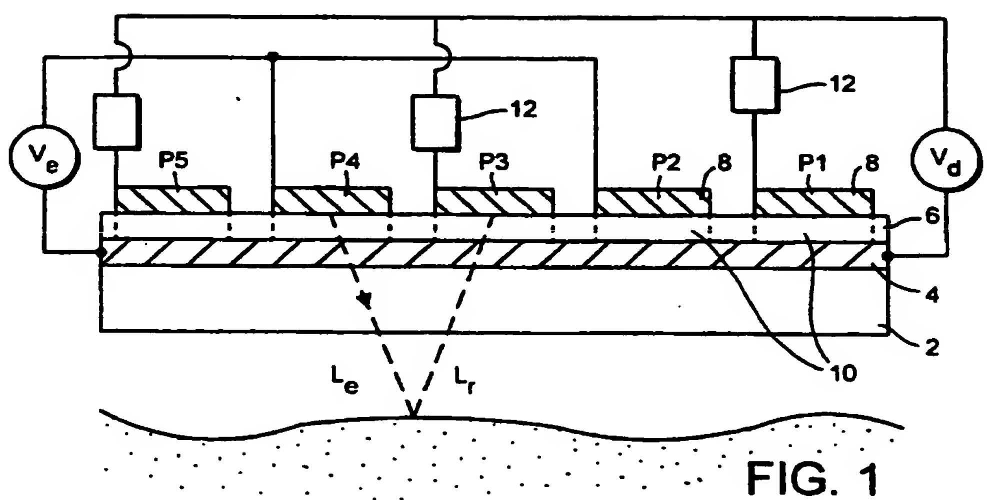

FIG. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

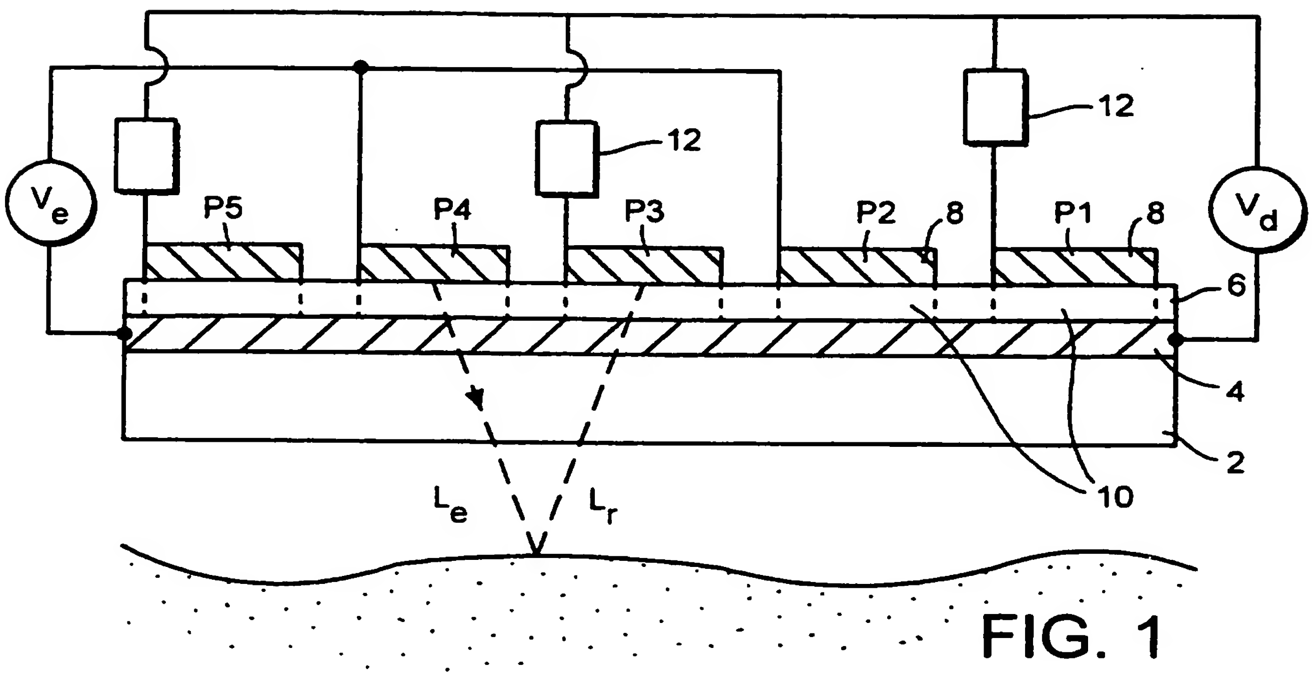

FIG. 1

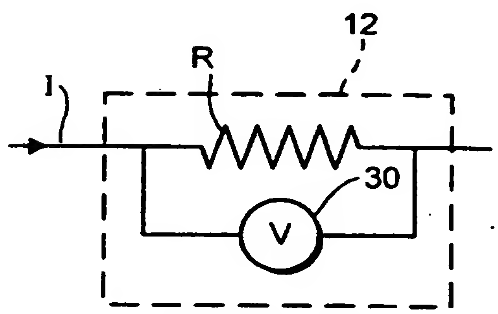

FIG. 1a

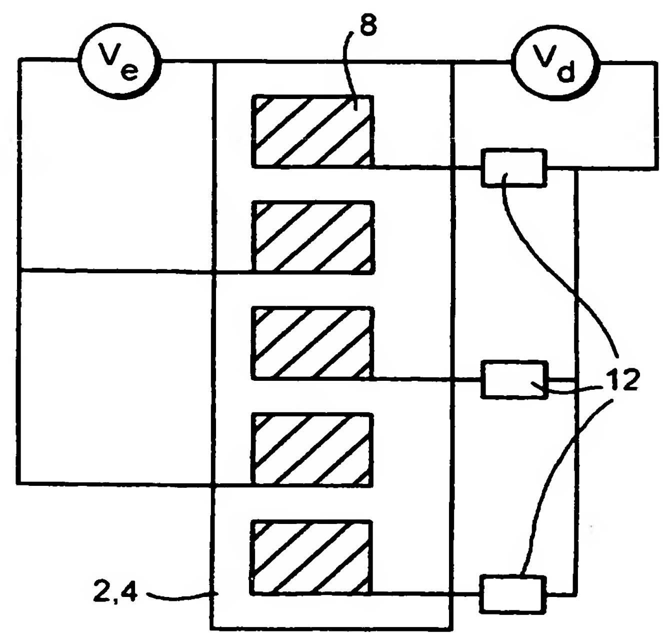

FIG. 2

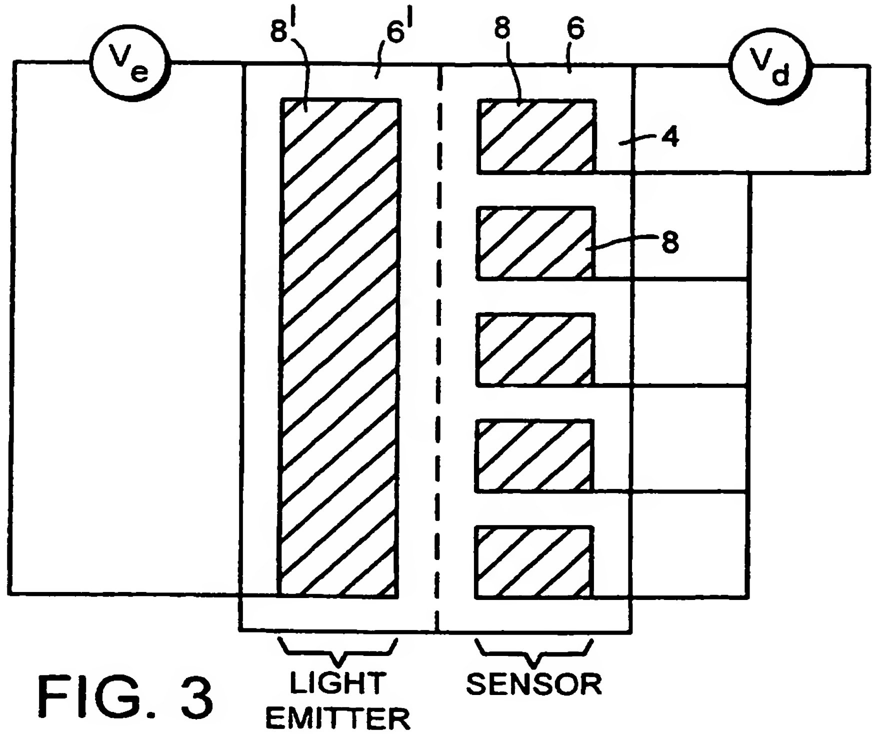

FIG. 3

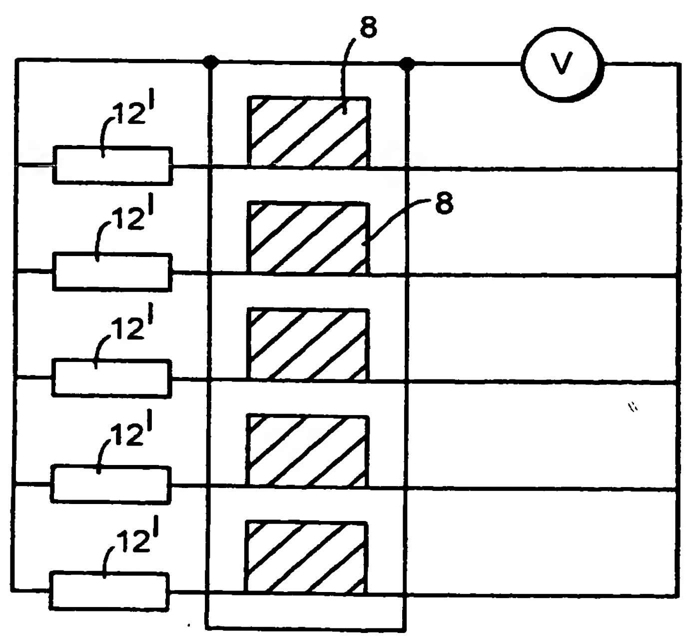

FIG. 4

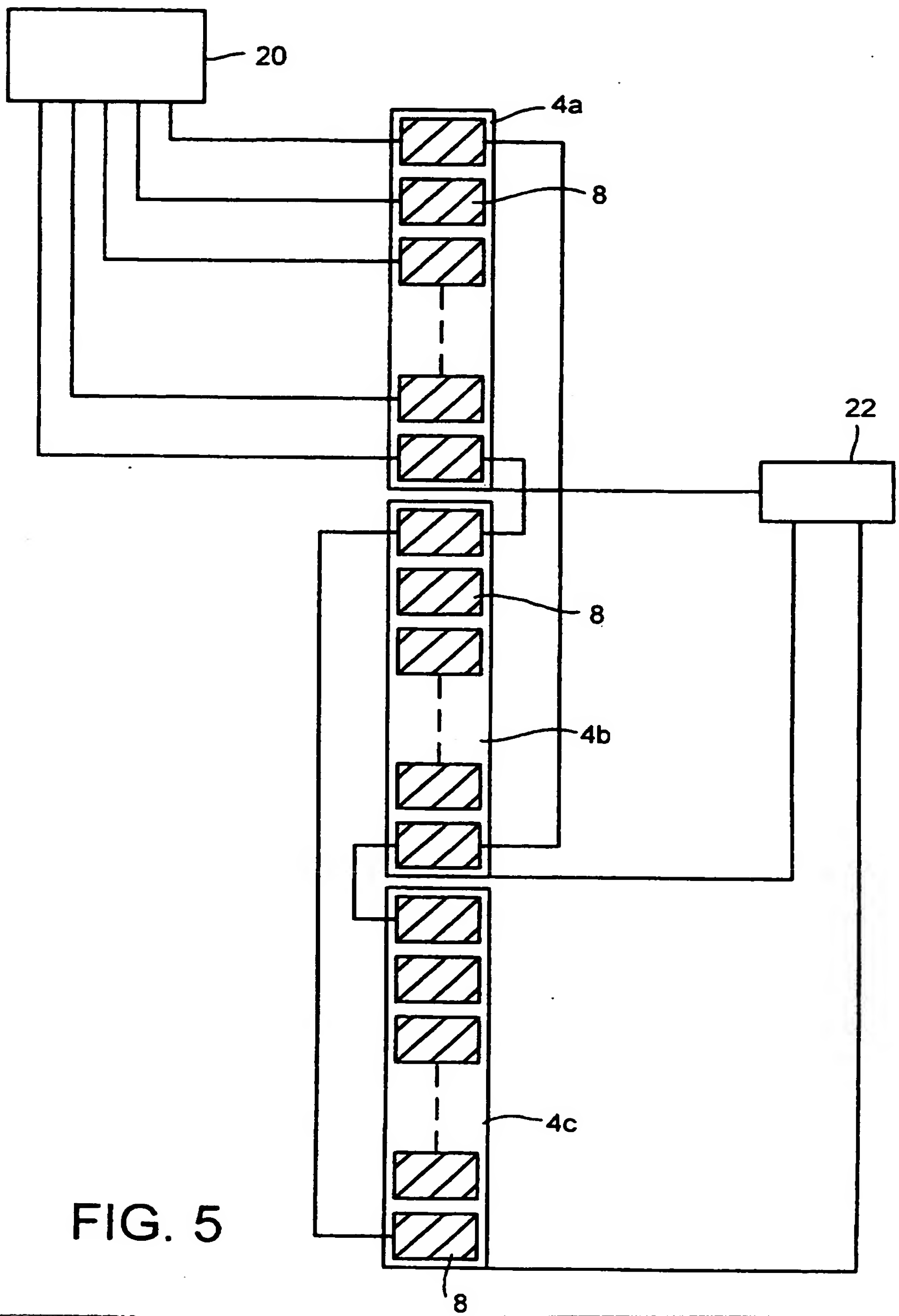

FIG. 5

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SENSING DEVICE

This invention relates to a sensing device and particularly to a sensing device comprising a single unit. The sensing device is particularly but not exclusively for scanning data from a surface by detecting light reflection from the surface.

Traditionally, such scanning devices have used bulk optic systems to image reflected light from the scanned object onto a charge coupled device (CCD). Charge coupled devices can be designed to have good sensitivities and scanning speeds. However, they are bulky. In many situations, the sensitivity and/or scanning speed is not a significant issue due to speed bottlenecks in other parts of the system, for example the telephone line band within a fax scanner, but instead the size of the scanning device is a more significant issue, particularly for portable systems.

More recently, a sensing device has been manufactured using a detector array defined in amorphous silicon and using contact coupling to the scanned image. Such a thin film contact image sensor is manufactured by Kyocera. In these sensing devices, a light source in the form of an array of light emitting diodes passes through the amorphous silicon layer defining the detection regions.

According to one aspect of the invention there is provided a unitary sensing device comprising:

a plurality of sensing elements defined in a sensing region of an organic layer, each sensing element being responsive to light reflected from an object to be sensed to generate a respective sensing signal; and

a light source comprising a light emitting region defined in an organic layer arranged in the same plane as said sensing region and between first and second electrodes, said light emitting region being operable to emit light when a potential difference is applied between the first and second electrodes.

A particularly suitable organic layer for defining the light emitting regions is a semiconductive conjugated polymer such as polyphenylene vinylene (PPV) or its derivatives. A semiconductive conjugated polymer layer can also be used as the layer for defining the sensing region. Another possibility is to use a light emitting organic molecular film such as described for example in C.W. Tang, S.A. Van Slyke and C.H. Chen, J. Appl. Physics 65, 3610 (1989).

The same polymer layer can be used to provide the sensing layer and the light emitting polymer layer. In one embodiment, a polymer layer is arranged between the first and second electrodes and provides interleaved sensing elements and light emitting elements. The arrangement of the first and second electrodes can be such that electrical connections can be made separately to the sensing elements and the light emitting elements so that they can be separately actuated. For example, an electric field may be required across the light emitting regions to cause them to emit light but the sensing elements may operate with no electric field applied to generate a sensing signal in response to light incident thereon. In that case, the sensing elements would merely be connected to sensing circuitry for receiving the sensing signals.

In another example, the light emitting elements have a voltage of one polarity applied across them and the sensing elements have a voltage of the opposite polarity applied across them.

In an alternative embodiment, the sensing elements and light emitting elements are arranged between the first and second electrodes and subject to the same potential. For this embodiment, the polymer is selected so that it has photoconductive qualities which lead to an increase in current flowing in the presence of incident light, this increase in current providing the sensing signal.

In an alternative embodiment, the light emitting polymer layer can be provided as a continuous strip adjacent a polymer strip defining a plurality of sensing elements.

Different polymer layers can be used to provide the light emitting polymer layer and the sensing layer.

The invention thus provides a unitary sensing device which may have a variety of different structures and which provides a device which is reduced in size and complexity by provision of the light source in the same plane as the detector array. Furthermore, there is an improvement in coupling efficiency because of the proximity of the source and scanned object.

For a better understanding of the present invention and to show how the same may be carried into effect reference will now be made by way of example to the accompanying drawings in which:

Figure 1 is a view from the side of one embodiment of a sensing device;

Figure 1a is a sketch of a suitable sensing circuit;

Figure 2 is a view from above of the sensing device of Figure 1;

Figure 3 is a view from above of a second embodiment of the sensing device;

Figure 4 is a view from above of a third embodiment of the sensing device; and

Figure 5 is a view from above of a fourth embodiment of a sensing device.

Reference will first be made to Figure 1 to describe one embodiment of a sensing device. The sensing device comprises a transparent substrate 2, for example glass, which is coated with indium tin oxide (ITO) to constitute a first electrode layer 4. In the embodiment of Figure 1, the layer of indium tin oxide extends over the whole region of the substrate 2

defining the sensing device. A polymer layer 6 is deposited on the indium tin oxide layer 4. The polymer layer 6 is preferably a semiconductive conjugated polymer, for example polyphenylene vinylene (PPV) or its derivatives. On the polymer layer 6 are defined respective electrodes 8 which are formed by separate regions of aluminium. The aluminium regions 8 define pixels in the polymer layer 6 below them. The polymer layer selected for use in this invention has the property of emitting light when an electric field is applied between the aluminium electrodes 8 and the ITO electrode 4. These electroluminescent qualities are discussed in detail in our earlier patent US-5247190, the contents of which are herein incorporated by reference. Application of an electric field between the two electrodes 4,8 on either side of the polymer layer 6 cause charge carriers of opposite types to be injected into the polymer layer. These charge carriers recombine and decay radiatively causing light to be emitted. Electrodes other than indium tin oxide and aluminium can be used, provided that the work functions of the electrodes are selected to allow injection of charge carriers of opposite types into the polymer layer. The polymer layer 6 can comprise more than one layer of polymer, for example a charge transport layer and a light emitting layer used adjacent one another.

The electrodes 8 each define respective pixels 10 in the polymer layer 6. In Figure 1, only five pixels are shown but it will readily be appreciated that a large number of such pixels will be present. In the embodiment of Figure 1, these pixels are divided into two sets, a sensing set and a light emitting set. For ease of reference the pixels 10 are labelled P1 through P5. Pixels P2 and P4 act as light emitting elements. To this end, a potential difference V_e is applied between the electrode layer 4 and the electrodes 8 associated with these pixels. When the potential difference V_e is applied, light is emitted from these pixels. This is denoted L_e in Figure 1, shown emitted only from pixel P4.

Generally, the light emitting pixels will all be actuated together and thus will all emit light together.

Pixels P1, P3 and P5 constitute sensing elements. These sensing elements detect light reflected from the object, marked L_r in Figure 1 and generate a respective sensing signal which is detected by a respective sensing circuit 12. To allow this sensing to occur, the sensing elements P1, P3 and P5 are connected to a voltage V_d having an opposite polarity to V_e. This effectively causes the polymer material defining the sensing element to act as a photoconductor and to become more conductive when light is incident thereon. Each sensing circuit 12 senses this increase in current.

Figure 1a is a sketch of a simple sensing circuit which can be used to provide a sensing signal. The sensing circuit 12 comprises a known resistance R and a voltage meter 30. The voltage meter 30 detects a voltage across the known resistance R, from which the current I flowing through the resistance R can be determined. When there is no light present, the measured voltage V equals i_1R. When light is incident, the measured voltage V equals i_2R.

$i_2 - i_1$ gives an indication of the reflected light intensity.

For a sensing element under forward bias, the following inequality is satisfied:

$$i_2 - i_1 \ll i_1.$$

For a sensing element under reverse bias, i_1 is approximately equal to zero and therefore i_2 gives an indication of the reflected light intensity.

The spacing between the sensing device and the surface of the object being scanned is optimal when the light emitted from adjacent light emitting elements just overlaps at the scanned surface. With this geometry, light from any particular point on the surface will be reflected to reach only one sensing element, and the resolution will be maximised.

Figure 2 is a plan view from above of the sensing device of Figure 1. It will be appreciated from these figures that the sensing elements and light emitting elements are interleaved along the line of a sensing array.

An alternative embodiment is shown in Figure 3. In this embodiment, the right hand side of Figure 3 has a construction similar to that described above with reference to Figure 1 but differing in that all of the electrodes 8 are connected to the voltage V_d to define them as sensing elements. Light is emitted from a separate light emitting region, shown on the left of Figure 3. This light emitting region has a construction similar to that shown in Figure 1 except that there is a continuous aluminium electrode 8' which extends the full length of the sensing arrangement defined by the electrodes 8. The voltage V_e is connected between the electrode 8' and the electrode 4. As shown in Figure 3, the sensing elements and light emitting region are defined in different polymer layers labelled 6 and 6' respectively. In that case, the emission wavelength of the polymer layer 6' constituting the light emitting region can be matched to the absorption maximum of the polymer material constituting the polymer layer 6 of the sensing elements. This can be achieved by the use of PPV as the emitter and a cyano derivative of PPV (poly(cyanoterephthalylidene) as the sensing layer. Poly(cyanoterephthalylidene has been reported in "Efficient light-emitting diodes based on polymers with high electron affinities" by N.C. Greenham et al in Nature, vol 365, pages 628-630.

The sensing elements and light emitting region could however be formed in the same polymer layer or in two different polymer layers of the same polymer material. The proximity of the light emitting region to the region defining the sensing elements is such that reflected light from the object being scanned is efficiently captured by the sensing array, with light from any point on the scanned surface being predominantly incident on only one sensing element.

In a still further embodiment, shown in Figure 4, a sensing array has a construction as shown in Figure 1 but with a common voltage V applied between each of the electrode regions 8 and the electrode 4. Each of the pixels thus formed acts as a light emitting element and as a sensing element. Light emission occurs as described earlier with reference to Figure 1 when the voltage V is applied. Sensing occurs by monitoring the reduction in forward bias voltage which is the result of light incident on a pixel. This reduction is monitored by respective sensing circuits 12', one being connected to each pixel. The photoconductivity of the polymer layer leads to a reduction in resistance in the presence of reflected light which for a given injection current will result in a reduced forward bias voltage. Therefore, each sensing circuit 12' is arranged to inject a constant current and to monitor the changes in forward bias voltage. Alternatively, if the pixels are driven at a constant voltage, the change in current due to detected light can be detected by the sensing circuits 12', as described above with reference to Figure 1.

The above-described sensing devices can be used as a proximity contact switch. An object such as a finger or pen brought close to the sensing device will reflect emitted light back into the sensing device and cause a change in the voltage or current across the device. These changes can be used to activate a switch (for example to determine which button has been pressed in an elevator) or to provide positioning information in a display (for example for pen-based input).

Alternatively, a light pen can be used to provide positioning information in a display, wherein the input light directly causes a change in the voltage or current across a sensing device. Alternatively, the sensing device can be used to change the brightness or light output of a device, depending on the surrounding ambient light. Thus, a display can be made brighter in a bright room, or dimmed in a darker room.

The sensing device can also be used to replace existing CCD and other scanning devices to input data by scanning a surface having light and dark patches representing the data. Thus, it can be used as a text reader in a fax or digital copier.

In the embodiments of Figures 1 to 4, only a small number of pixels is illustrated to simplify the diagrams and to make them clearer. In practice a large number of pixels will be included in a sensing device. A wire connection to each aluminium electrode is required to connect the pixel to its appropriate voltage and/or sensing circuitry. As the pixels will be small, it can be difficult to provide the required connections. One way of reducing the number of connections required from external circuitry to the sensing device is illustrated diagrammatically in Figure 5. Instead of the indium tin oxide layer 4 being continuous on the substrate, a plurality of distinct regions are formed, denoted 4a, 4b and 4c in Figure 5. For example there could be ten such regions. On each region, a number of electrode regions is formed according to the construction of Figure 1, for example there might be ten electrode regions for each region of the electrode layer 4. Pixels defined in the first region 4a are each respectively connected to sensing circuits of the type discussed above and which are indicated generally by the block 20 in Figure 5, Each pixel in the first region 4a is connected to a pixel in each of the other regions 4b, 4c. Not all of these connections are shown in Figure 5 for the sake of clarity. Each region of the indium tin oxide layer 4 can be individually addressed through a switch circuit 22. This thus

allows the selection to be made between the pixels which are connected together but overlying different regions of the electrode layer.

In one embodiment, there are ten regions in the electrode layer 4 and ten pixels in each region. The regions in the electrode layer 4 are sequentially addressed through application of a selection voltage to the electrode 4 and an appropriate voltage to the electrode region 8 of the individual pixels within each sub-array. The sensing signal for individual pixels is sequentially monitored by one of ten switching circuits in the block 20. Thus, only twenty external connections are required, ten for the selection of the regions in the electrode layer 4 and ten for the pixels overlying each region. Furthermore, only ten external sensing circuits are required.

CLAIMS:

1. A unitary sensing device comprising:

a plurality of sensing elements defined in a sensing region of an organic layer, each sensing element being responsive to light reflected from an object to be sensed to generate a respective sensing signal; and

a light source comprising a light emitting region defined in an organic layer arranged in the same plane as said sensing region and between first and second electrodes, said light emitting region being operable to emit light when a potential difference is applied between the first and second electrodes.

2. A sensing device according to claim 1, wherein the organic layer in which the light emitting regions are defined is a semiconductive conjugated polymer such as polyphenylene vinylene (PPV) or its derivatives.

3. A sensing device according to claim 1 or 2, wherein the organic layer for defining the sensing region comprises a semiconductive conjugated polymer.

4. A sensing device according to claim 1, 2 or 3, wherein a common organic layer provides the sensing layer and the light emitting polymer layer.

5. A sensing device according to claim 4, wherein the organic layer is arranged between the first and second electrodes and provides interleaved sensing elements and light emitting elements, the arrangement of the first and second electrodes can be such that electrical connections can be made separately to the sensing elements and the light emitting elements so that they can be separately actuated.

6. A sensing device according to claim 5, which comprises means for applying an electric field across the light emitting regions to cause them to emit light wherein the sensing elements operate with no electric field applied.

7. A sensing device according to claim 5, which comprises means for applying a voltage of one polarity applied across the light emitting elements and a voltage of the opposite polarity across the sensing elements.

8. A sensing device according to claim 4, wherein the sensing elements and light emitting regions are arranged between the first and second electrodes and subject to the same potential, the organic layer having been selected so that it has photoconductive qualities which lead to an increase in current flowing in the presence of incident light, this increase in current providing the sensing signal.

9. A sensing device according to claim 1, 2 or 3, wherein the organic layer in which the light emitting regions are defined is provided as a continuous strip adjacent a strip of the organic layer defining the sensing elements.

10. A sensing device substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

The Patent Office

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Application No: GB 9615319.2
Claims searched: 1-10

Examiner: E.L.Rendle
Date of search: 1 October 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H1K (KED)

Int Cl (Ed.6): H01L

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2 124 051 A	(EASTMAN KODAK) see whole document, especially figures 2 and 3.	-
A	EP 0 517 626 A1	(EASTMAN KODAK) see whole document, especially figures 1-5.	-
A	US 5 247 190 A	(CAMBRIDGE RESEARCH) see figure 2 and column 1 line 57 to column 2 line 7.	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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